

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of:

Richard B. Roth et al.

Serial No.: 10/723,681

Filing Date: November 25, 2003

Title: METHODS FOR IDENTIFYING RISK  
OF BREAST CANCER AND  
TREATMENTS THEREOF

Examiner: Sitton, Jehanne Souaya

Group Art Unit: 1634

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Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
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**DECLARATION OF DR. CHARLES CANTOR UNDER 37 C.F.R. 1.132**

Dear Sir:

I, Charles Cantor, declare as follows:

1. I have studied the human genome for a large part of my scientific career and a copy of my *curriculum vitae* is attached. I was Director of the Human Genome Center Project of the Department of Energy at Lawrence Berkeley Laboratory, and published the first textbook on genomics entitled *Genomics: The Science and Technology of the Human Genome Project*. I also was the Chair and Professor of the Department of Biomedical Engineering and Biophysics, and Director of the Center for Advanced Biotechnology, at Boston University. Before taking that position, I held professorship positions at Columbia University and the University of California, Berkeley. I have been the Chief Scientific Officer and Chairman of the Scientific Advisory Board of Sequenom, Inc. since 1998, and in May 2000 was appointed to the company's Board of Directors. I oversaw studies carried

out by the inventors that led to the scientific discoveries presented in the above-identified patent application.

2. I have reviewed the patent application and the rejection in the Office action dated September 13, 2006 based on a perceived lack of written description. I understand this perception may be addressed and overcome by showing the inventors had possession of the claimed methods at the time the patent application was filed. Below, I describe (i) methodology and discoveries presented in the patent application, (ii) genetic principles forming the basis for these discoveries, (iii) identification of another disease-associated locus using similar methodology, (iv) publicly available database information in support of the reported discoveries, and (v) other experimental evidence substantiating the discoveries. The data and methodology presented in the patent application and supporting evidence show the inventors had possession of the claimed methods at the time of filing.

3. Presented in the patent application is a genomic study in which many single nucleotide polymorphism (SNP) positions, spaced throughout the entire human genome, were typed in two populations: a breast cancer population and a "healthy" control population. Certain variants occurring with a significantly high frequency in the cancer population were identified as markers residing in candidate loci associated with the disease. The inventors then verified that additional SNPs proximal to the incident marker polymorphism in each locus were significantly associated with the disease. Regions that contained multiple disease-associated polymorphisms were verified as being significantly associated with breast cancer. One region identified by this method was a region encoding the MAPK10 protein, and the inventors typed 60 polymorphic sites in this region. Of these, several polymorphisms were significantly associated with breast cancer, and they clustered in sub-regions of the MAPK10 locus. These sub-regions, or "hot zones," are the regions specified in amended claim 1, and illustrated in Figure 15 of the patent application. Thus, the inventors identified that the MAPK10 region was significantly associated with breast cancer by (i) identifying a locus containing an incident polymorphic marker associated with

the disease in a genome-wide scan, and (ii) verifying multiple polymorphic sites proximal to the incident marker in the locus also were associated with the disease.

4. Identifying a disease-associated region by this methodology is supported by accepted genetic principles. The concept of linkage disequilibrium in genetics embodies the phenomenon that a disease-associated region in the human genome contains a cluster of polymorphisms associated with a disease state. Specifically,

markers very close to the disease gene will tend, more likely than average, to retain the haplotype of the original chromosome because, as the distance to the disease gene shrinks, it becomes less likely that recombination events will have occurred in this particular region.

From Cantor & Smith, *Genomics: The Science and Technology Behind the Human Genome Project*, 1999, John Wiley & Sons, Inc., New York, page 192. Thus, identifying multiple polymorphisms associated with a disease state within a region identifies the region as associated with the disease state. Accordingly, the inventors identified the claimed regions as being associated with breast cancer when they verified multiple polymorphic variants in the regions were significantly associated with the disease.

5. Identifying a disease-associated region by this methodology is supported by the work of other researchers. Researches using similar methods independently located a complement factor H (CFH) gene region as being significantly associated with age-related macular degeneration (AMD). Klein *et al.*, like the inventors of the present patent application, screened SNPs spaced across the entire human genome in disease and control populations, and identified polymorphisms significantly associated with the disease<sup>1</sup>. Klein *et al.* then sequenced exons in the locus containing the associated SNPs and identified proximal polymorphisms associated with the disease. Edwards *et al.*, screened proximal polymorphisms in the CFH region and identified a sub-region particularly associated with the disease<sup>2</sup>. Edwards *et al.* illustrated the disease-associated region

using a plot similar to Figure 15 in the present patent application (Figure 1 in Edwards *et al.*). Haines *et al.* also identified the same CFH gene region as being associated with AMD from a 261 kilobase pair region containing a haplotype associated with AMD<sup>3</sup>. Like Edwards *et al.*, Haines *et al.* illustrated the disease-associated region using a plot similar to Figure 15 in the present patent application (Figure 2 in Haines *et al.*). Hageman *et al.* and Zarepari *et al.* further confirmed the association of the CFH region with AMD<sup>4,5</sup>.

6. I would like to point out that the inventors typed a significant number of polymorphisms in the MAPK10 region in the process of determining that the region was associated with breast cancer. The following table shows, according to the MAPK10 region analyzed and the sub-regions claimed, (i) the number of polymorphisms the inventors analyzed, (ii) the number of polymorphisms in the HapMap database, (iii) the number of polymorphisms analyzed by the inventors overlapping with the HapMap database polymorphisms, (iv) the number of polymorphisms in the HapMap database having a minor allele frequency (MAF) of greater than 0.05, and (v) the number of polymorphisms analyzed by the inventors overlapping with the HapMap database polymorphisms having a MAF greater than 0.05. Sub-regions 1, 2, 3 and 4 correspond to regions bounded by chromosome positions 87330326-87342924, 87352676-87369072, 87311012-87314967 and 87320287-87320855, respectively.

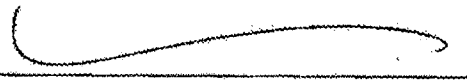
Region	Inventor polymorphisms (IP)	HapMap polymorphisms (HP)	Overlap of IP and HP	HP with MAF >0.05 (HP>0.05)	Overlap of IP and HP>0.05
MAPK10	60	133	34 (26%)	53	30 (57%)
sub-region 1	15	18	11 (61%)	12	10 (83%)
sub-region 2	6	19	4 (21%)	11	3 (27%)
sub-region 3	2	4	1 (25%)	3	1 (33%)
Sub-region 4	3	1	1 (100%)	1	1 (100%)

In the claimed sub-regions, the inventors therefore analyzed 83%, 27%, 33% and 100% of the polymorphisms currently in the HapMap database having a MAF of greater than 0.05 at the time the present patent application was filed (i.e., November 25, 2003), which was more

than three-and-a-half years ago. This degree of overlap with polymorphisms in the HapMap database is on par with, or better than, the overlap of polymorphisms Klein *et al.* analyzed for determining the association of CFH with AMD. Specifically, Klein *et al.* analyzed 13% of the CFH region SNPs in the HapMap database (analyzed 19 of 152 in the database; paragraph spanning pages 386-387). The inventors therefore identified the claimed MAPK10 sub-region association with breast cancer by analyzing a significant number of polymorphisms.

7. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Executed in San Diego, California, on 25 July 2007.



Charles Cantor, Ph.D.

Documents cited:

1. Klein *et al.*, "Complement factor H polymorphism in age-related macular degeneration," *Science* 308: 385-389 (2005).
2. Edwards *et al.*, "Complement factor H polymorphism and age-related macular degeneration," *Science* 308: 421-424 (2005).
3. Haines *et al.*, "Complement factor H variant increases the risk of age-related macular degeneration," *Science* 308: 419-421 (2005).
4. Hageman *et al.*, "A common haplotypes in the complement regulatory gene factor H (HF1/CFH) predisposes individuals to age-related macular degeneration," *Proc. Natl. Acad. Sci.* 102(20): 7227-7232 (2005).
5. Zarepari *et al.*, "Strong association of the Y402H variant in complement factor H at 1q32 with susceptibility to age-related macular degeneration," *Am. J. Hum. Genet.* 77: 149-153 (2005).

## Charles R. Cantor, PhD

**Academic Qualifications:** Columbia University, A.B., 1963. University of California, Berkeley, California US, PhD. 1966.

**Academic Qualifications:** 1966-69, Asst. Prof. of Chemistry, Columbia Univ.; 1969-72, Assoc. Prof. of Chemistry, joint appointment in Biological Sciences, Columbia Univ.; 1972-81, Prof. of Chemistry, joint appointment in Biological Sciences, Columbia Univ.; 1981-89, Prof. and Chair of Genetics and Development, College of Physicians and Surgeons, Columbia Univ., Deputy Dir. for Education, 1981-85, Comprehensive Cancer Ctr., and Deputy Dir. for Biotechnology, 1985-88, Comprehensive Cancer Ctr.; 1988-89, Higgins Prof. of Genetics and Development, Faculty of Medicine, Columbia Univ.; 1988-90, Dir., Human Genome Ctr., Lawrence Berkeley Laboratory; 1989-91, Sr. Biochemist, Cell and Molecular Biology Div., Lawrence Berkeley Laboratory; 1989-92, Prof. of Molecular Biology, Univ. of CA, Berkeley; 1990-92, Principal Scientist, Human Genome Project, U.S. Dept. of Energy; 1991-92, Sr. Biochemist, Chemical Biodynamics Div., Lawrence Berkeley Laboratory; 1992-pres., Prof. of Biomedical Engineering, Boston Univ.; 1992-pres., Dir., Ctr. for Advanced Biotechnology, Boston Univ.; 1994-pres., Prof., Pharmacology Dept., Boston Univ. Medical School; 1995-98, Chair, Dept. of Biomedical Engineering, Boston Univ.; 1998-pres., Chief Scientific Officer, Sequenom, Inc.; 2002, Founder, SelectX Pharmaceuticals, Inc.; 2005, Founder, Retrotope, Inc.

**Present Positions:** Boston University, Boston, MA USA, co-director of the Center for Advanced Biotechnology and professor of Biomedical Engineering. Sequenom, Inc., San Diego, CA USA, Chief Scientific Officer, founder and member, Board of Directors.

**Research Work and Funding:** Large projects including Director of the Human Genome Center of the Department of Energy at Lawrence Berkeley Laboratory. 35 years of continuous research funding from government and private sources.

### Awards and Honors:

1969-71, Fellow of the Alfred P. Sloan Foundation; 1972, Fresenius Award in Chemistry; 1973-74, Guggenheim Fellow; 1975-76, Fairchild Distinguished Visiting Scholar, CA Inst. of Technology; 1978, Eli Lilly Award in Biological Chemistry; 1981, Fellow of the Amer. Assoc. for the Advancement of Science; 1985, Outstanding Investigator Grant, Natl. Cancer Inst.; 1988, Biochemical Analysis Prize of the German Society of Clinical Chemistry; 1988, Member of the Natl. Acad. of Sciences; 1988, Member of the Amer. Acad. of Arts and Sciences; 1989, ISCO Award for Advances in Biochemical Instrumentation; 1990, Herbert A. Sober Award, Amer. Society for Biochemistry and Molecular Biology; 1990, Honorary Member, Japanese Biochemical Society; 1992, Fellow of the CA Acad. of Sciences; 1993, Fellow of the Biophysical Society; 2000, Emily M. Gray Award from the Biophysical Society; 2002, Chief Scientist of the Year, T Sector and BIOCOM; 2004, Ohio State University Human Cancer Genetics Program Commemorative Medal for Excellence in Research and Clinical Care

### Selected Publications since 2004:

Smylie, K.J., Cantor, C.R., and Denissenko, M. 2004. *Analysis of Sequence Variations in Several Human Genes using Phosphoramidite Bond DNA Fragmentation and Chip-based MALDI-TOF*. Genome Research, 14, 134-141.

Karaoz, U., Murali, T.M., Letovsky, S., Zheng, Y., Ding, C., Cantor, C.R., and Kasif, S. 2004. *Whole Genome Annotation Using Evidence Integration in Functional Linkage Networks*. Proc. Nat. Acad. Sci. USA, 101, 9, 2888-2893.

Ding, C., Maier, E., Roscher, A.A., Braun, A., and Cantor, C.R. 2004. *Simultaneous Quantitative and Allele-specific Expression Analysis with Real Competitive PCR*. BMC Genetics 2004:5:8

Antonenko, Y.N., Rokitskaya, T.I., Kotova, E.A., Reznik, G.O., Sano, T., and Cantor, C.R. 2004. *Effect of Streptavidins with Varying Biotin Binding Affinities on the Properties of Biotinylated Gramicidin Channels*. Biochemistry 43, 4575-4582.

Kobayashi, H., Kaern, M., Araki, M., Chung, K., Gardner, T.S., Cantor, C.R., and Collins, J.J. 2004. *Programmable Cells: Interfacing Natural and Engineered Gene Networks*. Proc. Nat. Acad. Sci. USA, 101, 22, 8414-8419.

Isaacs, F.J., Dwyer, D.J., Ding, C., Pervouchine, D.D., Cantor, C.R., and Collins, J.J. 2004. *Engineered Riboregulators Enable Post-transcriptional Control of Gene Expression*. Nature Biotech., 22, 841-847.

Ding, C., Chiu, R.W.K., Lau, T.K., Leung, T.N., Chan, L.C., Chan, A.Y.Y., Charoenkwan, P., Ng, I.S.L., Law, H., Ma, E.S.K., Xu, X., Wanapirak, C., Sanguansermsri, T., Liao, C., Tan Jin Ai, M., Chiu, D.H.K., Cantor, C.R., and Lo, Y.M. Dennis. 2004. *Mass Spectrometry Analysis of Single-nucleotide Differences in Circulating Nucleic Acids: Application to Noninvasive Prenatal Diagnosis*. Proc. Nat. Acad. Sci. USA, 101, 29, 10762-10767.

Nelson, M.R., Marnellos, G., Kammerer, S., Hoyal, C.R., Shi, M.M., Cantor, C.R., and Braun, A. 2004. *Large-scale Validation of Single Nucleotide Polymorphisms in Gene Regions*. Genome Research, 14, 1664-1668.

Zhang, L., Kasif, S., Cantor, C.R., and Broude, N.E. 2004. *GC/AT-content Spikes as Genomic Punctuation Marks*. Proc. Nat. Acad. Sci. USA, 101, 16855-16860.

Kammerer, S., Roth, R.B., Reneland, R., Marnellos, G., Hoyal, C.R., Markward, N.J., Ebner, F., Kiechle, M., Schwarz-Boeger, U., Griffiths, L.R., Ulbrich, C., Chrobok, K., Forster, G., Praetorius, G.M., Meyer, P., Rehbock, J., Cantor, C.R., Nelson, M.R., and Braun, A. 2004. *Large-Scale Association Study Identifies ICAM Gene Region as Breast and Prostate Cancer Susceptibility Locus*. Cancer Research, 64, 8906-8910.

Honisch, C., Raghunathan, A., Cantor, C.R., Palsson, B.O., and van den Boom, D. 2004. *High-throughput Mutation Detection Underlying Adaptive Evolution of Escherichia Coli-K12*. Genome Research, 13, 2495-2502.

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- Rachlin, J. Ding, C., Cantor, C.R., and Kasif, S. 2005. *Computational Tradeoffs in Multiplex PCR Assay Design for SNP Genotyping*. BMC Genomics, 6, 102.
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- Demidov, V., Dokholyan, N., Witte-Hoffman, C., Chalasani, P., Yiu, H-W., Ding, F., Yu, Y., Broude, N., and Cantor, C.R. 2006. *Fast Complementation of Split Fluorescent Protein Triggered by DNA Hybridization*. Proc. Nat. Acad. Sci. USA, 103, 2052-2056.
- Guido, N.J., Wang, X., Adalsteinsson, D., McMillen, D., Hasty, J., Cantor, C.R., Elston, T.C., and Collins, J.J. 2006. *A Bottom-up Approach to Gene Regulation*. Nature, 439, 856-860.
- Herring, C.D., Raghunathan, A., Honisch, C., Patel, T., Applebee, M. K., Joyce, A.R., Albert, T.J., Blattner, F.R., van den Boom, D., Cantor, C.R. and Palsson, B.O. 2006. *Comparative genome sequencing of Escherichia coli allows observation of bacterial evolution on a laboratory timescale*. Nat. Gen. 38, 12, 1406-1412.
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- Zhang, L., Kasif, S., Cantor, C.R. 2007. *Quantifying DNA-protein binding specificities by using oligonucleotides mass tags and mass spectrometry*. Proc. Nat. Acad. Sci. USA, 104, 3061-3066.
- Honisch, C., Chen, Y., Mortimer, C., Arnold, C., Schmidt, O., van den Boom, D., Cantor, C.R., Shah, H. N., Gharbia, S.E. 2007. *An automated comparative sequence analysis approach: Microbial typing by base-specific cleavage and MALDI-TOF mass spectrometry*. Proc. Nat. Acad. Sci. USA, in process.

#### **Selected Recent Professional Affiliations and Service:**

1976-pres., Series Editor, Advanced Textbooks in Chemistry, Springer-Verlag, New York; 1978-pres., Biophysical Society (Council Member, 1978-81); 1982-pres., Amer. Society of Biochemistry and Molecular Biology; 1984-pres., Nomenclature Commission of the Intl. Union of Biochemistry and Molecular Biology; 1985-pres., Scientific Advisory Council, Roswell Park Memorial Inst.; 1988-pres., Biomedical Advisory Committee, Pittsburgh Supercomputing Ctr.; 1988-pres., Cell and Membrane Transport Commission, Intl. Union of Pure and Applied Biophysics; 1988-pres., Member, Exec. Committee and Founding Council, Intl. Human Genome Organization (HUGO) and 1990-2006, Vice President; 1991-95, Chair, HUGO Human Genome Mapping Committee (HGMC); 1992-1996, President, HUGO Americas; 1988-pres., Editorial Board, *Current Opinion in Biotechnology*; 1992-97, Member, Board of Dir., Chair, Scientific Advisory Board, ATGC/AT Biochem, Inc.; 1992-02, Member, Advisory Board, Boston Univ. Journal of Science Technology and Law; 1994-pres., Co-chair, Biotechnology Advisory Committee, Fisher Scientific; 1996-pres., Member, Editorial Board, *Biotechniques*; 1996-97, Member, NRC Committee, "Bits of Power"; 1997-98, Member, DARPA Advisory Committee on Biological Warfare Defense; 1996-2000, Member, Advisory Board, Encyclopedia of Molecular Biology; 1996-00, Member, FASEB Consensus



Committee on Federal Funding, representing the Biophysical Society; 1997-2000, Quest Scholar, Quest Diagnostics, Inc., San Juan Capistrano, CA; 1998-2000, Member, Defense Intelligence Agency Bio 2020 Red Team, Washington, D.C.; 2000-pres., Adjunct Prof., Dept. of Bioengineering, UCSD; 2001-pres., Science Advisory Board, Brandeis Univ. School of Science; 2002, Advisory Committee Member, Stockholm Strategic Research Foundation; 2002-pres., Scientific Advisory Board, Buffalo Ctr. of Excellence in Bioinformatics; 2003-pres., Member, National Advisory Board, Boston University Research Center for Translational Genomics and Human Rights, Boston, MA; 2004-pres., Scientific Advisory Board, Joint Center for Structural Genomics, La Jolla, CA; 2004-pres., Scientific Advisory Board, Uppsala Bio-X, Uppsala, Sweden. Currently Board member or advisor for 20 or more companies including Fisher Scientific, US, Techno Ventures Management (Germany), Strand Genomics (India). 44 issued U.S. patents.